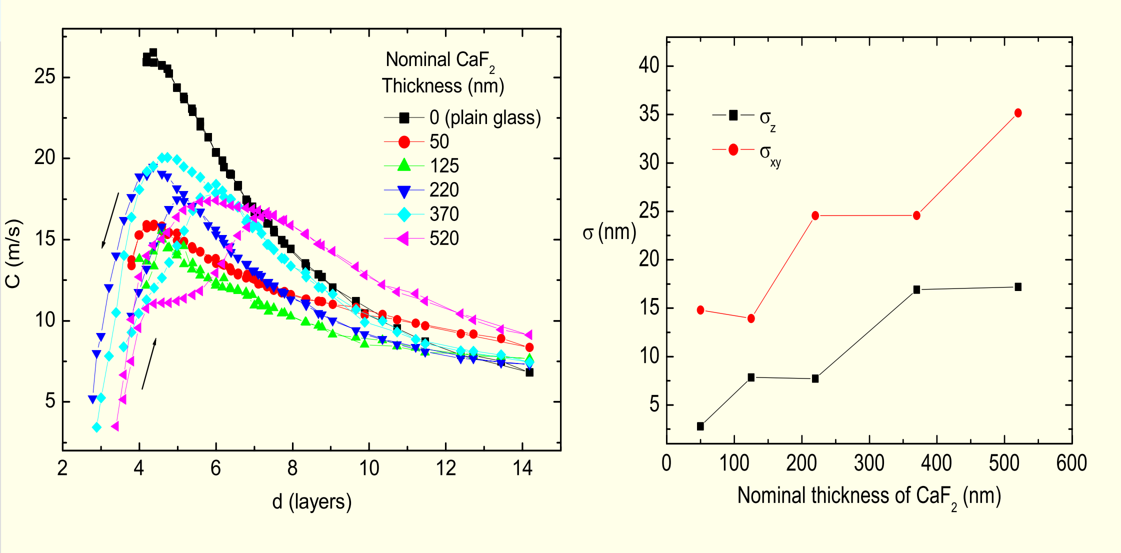
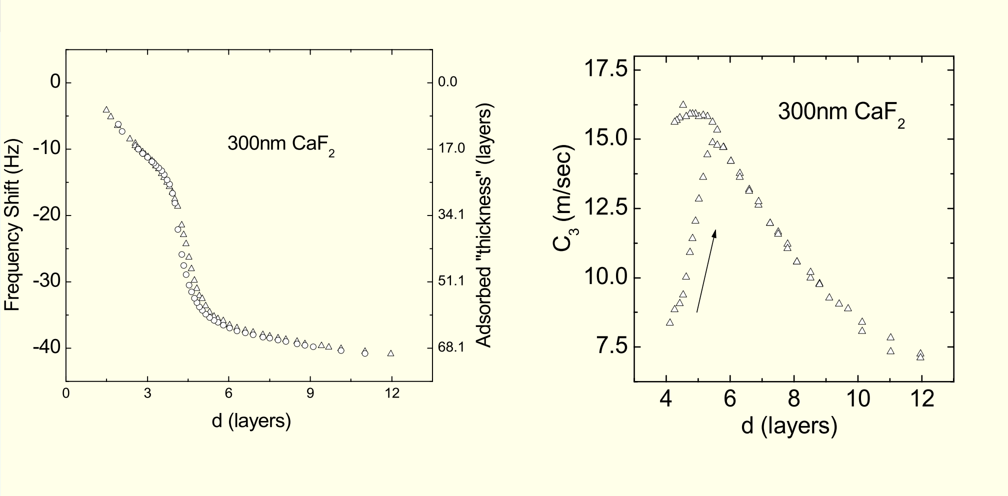
With the support of NSF DMR-0138009 we are determining the propagation properties of waves known as third sound on thin superfluid ^4He films adsorbed onto surfaces with roughness determined by AFM measurements and the mass coupling of such films to the same rough surfaces deposited onto quartz microbalances. One goal is to understand the Kosterlitz-Thouless phase transition behavior on such surfaces. Another is to determine their suitability for studies of localization in two dimensions and search for the predicted shift of universality class when a symmetry breaking field is applied.

Here is shown the velocity of third sound on various CaF_2 surfaces vs. ^4He film thickness on glass, d, at 1.671 K for the nominal thicknesses of CaF_2 shown in nm.



Data were taken while adding ^4He to the cell until d = 14.2 layers. Then the ^4He was removed. Hysteresis is easily seen on the samples with 220, 370 and 520 nm of CaF_2. This is caused by capillary condensed ^4He absorbed in the porous structure of the rough CaF_2. Also shown here is AFM-determined topography described next.

Several atomic force microscopy (AFM) images were taken of each sample. From these we calculate a typical size for the perpendicular topography, σ_z, and also a typical size for the parallel topography, σ_{xy}. A plot of σ_z and σ_{xy} versus nominal thickness of the CaF_2 is shown on page #1. By measuring the average height of the CaF_2 relative to the glass surface, we are able to calculate the porosity (ratio of the pore volume to the total volume) of each CaF_2 sample and find p = 0.42 +/- 0.06.



Earlier measurements from our lab for nominal 300 nm CaF_2 are shown for a quartz crystal microbalance and for third sound at T = 1.555 K. Although there is a clear superfluid transition in the third sound data, there is no frequency jump in the quartz crystal data, which shows large uptake. The absence of a visible Kosterlitz-Thouless frequency shift in the quartz crystal data, even when examined to high resolution, is intriguing. This is not yet understood. A frequency shift of the expected size is observed (not shown here) on the quartz crystal in the absence of the rough CaF_2.

This work should elucidate features of the Kosterlitz-Thouless transition in complex geometries, and future work on localization will test current theories of wave propagation in complex environments in the presence of a symmetry breaking field.

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